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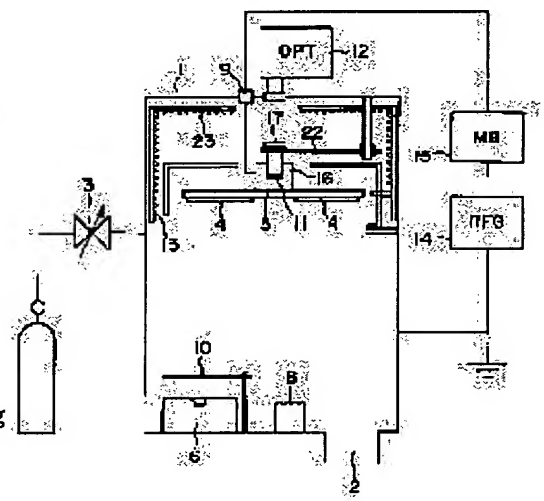
(54) OPTICAL THIN FILM PRODUCING SYSTEM

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an optical thin film producing system capable of efficiently producing an optical thin film element having desired characteristics at a high packing ratio in a short time.
SOLUTION: This system is equipped with a mechanism for applying high frequency electric power to a rotating substrate dome 5 and heating a substrate 4 for making the device usable also for the conventional vacuum deposition method. In order for efficiently applying high frequency electric power even in the case the substrate dome lies in a high temp. state, a high frequency electric power feeding mechanism 16 composed of tungsten disulfide (WS2) or molybdenum disulfide (MoS2) as a self-lubricant is provided. At the time of feeding the electric power equal to the high frequency electric power to be applied to the substrate domes to a monitoring substrate 11, for suppressing abnormal discharge, a monitor cylinder 17 and a monitor set plate 22 are insulated from a vacuum tank 1 by using an insulating member. Moreover, for suppressing abnormal discharge between the substrate dome and a substrate heating heater dome 23, a shield 13 fitted between the dome is provided with a mesh structure.



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CLAIMS

[Claim(s)]
[Claim 1] Optical thin-film-fabrication equipment characterized for the device in which high-frequency power is directly impressed to a substrate dome by the mounting beam thing in the equipment which manufactures an optical (dielectric) thin film in order to obtain the optical thin film of high pack density all over a substrate dome.
[Claim 2] Optical thin-film-fabrication equipment according to claim 1 characterized by having the high-frequency power feed device which consists of self-lubricant in order that the substrate dome to rotate may impress high-frequency power efficiently also in the state of an elevated temperature.
[Claim 3] Optical thin-film-fabrication equipment according to claim 1 characterized by making a monitor cylinder and a monitor set plate into the structure insulated from a vacuum tub using an insulating member in order to control abnormality discharge, in case the same power as the high-frequency power impressed to a substrate dome is impressed also to a monitoring substrate.
[Claim 4] Optical thin-film-fabrication equipment according to claim 1 characterized by the ability to carry out substrate heating efficiently by making mounting beam shielding into mesh structure among both in order to control the abnormality discharge between a substrate dome and a substrate heating heater dome.
[Claim 5] Optical thin-film-fabrication equipment according to claim 1 characterized by having the device which can carry out adjustable [of the shielding spacing of a substrate dome and a periphery] in order to improve the refractive index of the substrate laid in the substrate dome periphery section.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to optical thin-film-fabrication equipment and its structure.
[0002]
[Description of the Prior Art] In order to use the cross protection of light for an optical thin film, it needs to acquire the property of carrying out observation control and asking for optical thin film thickness:nxd (n: a refractive index, d:physics thickness) of a dielectric. There is thermal reflex film given to the antireflection film and the die clo IKKU (2 color separation) mirror further for liquid crystal visions which are given to the front panel of various lenses, such as glasses and CD pickup, and OA equipment etc., a cold mirror, a windowpane for building materials for lighting, etc. as a common application product. moreover -- as industrial use -- recently -- especially -- extension -- a band pass filter (BPF), a deflection demarcation membrane filter (PBS) for DVD, etc. which are used as an ultra-narrow band pass filter of the stepper light source which is the important point of optical communication, such as LAN expected to elongate greatly with remarkable mobile communications from now on, and the detailed pattern formation of a VLSI device are raised as a typical optical thin film. In such the optical thin film industry and the electronic-parts related industry, a technique which forms the optical thin film of high pack density efficiently on substrate ingredients, such as glass, a semi-conductor, a metal, and ceramics, for a short time is desired strongly.
[0003] This kind of thin film places the quality of an emission conventionally on the plate of the molybdenum which is made to short-circuit the 2 inter-electrode installed in the lower part in the high vacuum container made to exhaust to about 10 - 4Pa as an evaporation source and which has been arranged like, or a tungsten. The resistance heating evaporation source which 2 inter-electrode is made to impress and heat alternating current power (possible also at direct current voltage), and is evaporated, The vacuum deposition method which forms membranes to the substrate arranged in the location which used the electron gun heating evaporation source which is completed as the quality of an emission, is made to heat a thermoelectron using an electron gun, and is evaporated, and countered these evaporation sources, Or the plasma production equipment (plasma gun) made to generate the ion generation equipment (ion gun) which makes the lower part in the high vacuum container made to exhaust to about 10 - 4Pa generate ion, and the plasma is arranged. It was common to have been manufactured by the forming-membranes method used together with a vacuum deposition method, making ion and the plasma generate from an ion gun or a plasma gun.
[0004] Inside the vacuum tub (1) which drawing 1 is what showed the schematic diagram of the method of forming membranes while generating ion and the plasma, and was equipped with evacuation opening (2) and a gas inlet (3) A substrate (4) in a mounting beam substrate dome (5) and the location which counters An evaporation source (6) and an ion gun (7), A thermionic emission device (8) is established and this substrate dome (5) currently installed with the lead wire passing through the inside of an insulator (9) is rotated through a substrate dome rolling mechanism from the motor for a substrate dome revolution of the exterior which it is heated by the heating heater dome (23), and is not illustrated. Moreover, between this substrate dome (5) and an evaporation source (6), a shutter (10) is prepared free movable, and it is going to obtain a desired optical thin film, carrying out observation control of the optical thin film deposited on the monitoring substrate (11) further installed in the monitor cylinder (17) by the external optical thickness gage (12).
[0005] A vacuum tub (1) is beforehand exhausted with pumps (not shown), such as a cryopump, through evacuation opening (2) to a high vacuum field (about 10 - 4Pa). The gas for discharge, such as Ar and oxygen,

is introduced from the blasting-fumes inlet (3) to 20sccm extent ion gun (7). Furthermore, oxygen gas etc. is introduced to a vacuum tub (1) to a request pressure (about 8x10-3 to 3x10 - 2Pa). Power (600W-3600W) is supplied from an evaporation source (not shown) in this condition, and power is supplied and is made to discharge to an ion gun (7) further. From said ion gun, on a substrate, the ion current by which outgoing radiation was carried out is controlled suitably, and is irradiated. Membranes are formed carrying out observation control of the optical thin film which releases an evaporation source shutter (10) here and is deposited on a monitoring substrate (11) by the optical thickness gage (12), an evaporation source shutter (10) is closed by desired thickness, and membrane formation is completed.
[0006] On the other hand in metal thin-film-fabrication equipment, as equipment which generates an adhesive good metal coat on insulating material ingredients, such as plastics, glass, and ceramics The particle which is shown in JP,51-23376,B and which evaporated from the evaporation source like With the configuration which cation-izes, is accelerated by the direct-current negative electric field by which induction is carried out on a substrate by impressing high-frequency voltage (about 13MHz) to a substrate, is made to rush into a substrate front face, and generated the thin film by passing the inside of the plasma of high density The ion of a particle can be made to invade to the number atomic layer on the front face of a substrate, and the case where the adhesion of a metal coat has been improved remarkably is introduced.
[0007] Generally, the laminating of the dielectric film of high / low refractive index is carried out on substrates, such as glass, by turns by the vacuum deposition method, and an optical thin film may amount to 50 or more layers depending on a component. For this reason, if the pack density (Packing density) of a thin film is low, the stable engine performance will be hard to be obtained that it is easy to produce aging under the effect of humidity (H_2O). the case of the near-infrared region BPF which formed about 20-30 layers with the vacuum deposition method -- the environmental variation (example: 25-degree-C50%->80-degree-C95%) of temperature humidity -- the spectral characteristic -- a long wave -- about 50nm moves to a merit side (wavelength shift). For example, when the optical thin film used in the field of optical communication carries out a wavelength shift, trouble is given to a communication link or there are problems, like a communication link becomes impossible.
[0008] As a means to aim at improvement in the pack density of an optical thin film, there is a method used together with a vacuum deposition method, making the ion and plasma from the above ion guns or a plasma gun irradiate a substrate. Ion generation equipment (ion gun) and plasma production equipment (plasma gun) can be installed in the interior of equipment, and an optical thin film with few (about 1nm shift amount) amounts of wavelength shifts can be obtained by forming membranes, using ion and the plasma together. However, since directivity will arise in bleedoff distribution of ion or the plasma if an ion gun and a plasma gun are used, uneven distribution arises in the refractive index of the thin film formed by an ion gun and plasma gun generation equipment on the substrate dome by which opposite arrangement was carried out. When an ion gun and a plasma gun are used, the area where a refractive index becomes practically uniform cannot obtain the thin film of the property of asking only for a substrate dome core by (10 - 20% of the whole substrate dome surface product).
[0009] The membrane formation processing time also requires long duration considerably from a vacuum deposition method. Moreover, at the time of BPS filter membrane formation of about 30 layers As opposed to forming membranes by 0.5 nm/s, low refractive-index matter:1.0nm/about s, and ending with about 2-hour time amount one process a vacuum deposition method -- a vapor rate -- high refractive-index matter: -- The membrane formation rate at the time of using an ion gun and a plasma gun High refractive-index matter: In order to form membranes with 0.1 nm/s and low refractive-index matter:0.5 nmn/s extent and to require about 5 times as many time amount as this as compared with 1 process 10 hours, and a vacuum deposition method, it was dramatically difficult to form a desired optical thin film with sufficient productive efficiency. With the equipment shown in JP,51-23376,B, shielding is prepared in the substrate dome upper part. When a substrate heater dome is located in the shielding upper part and it generates by heating a substrate at about 300 degrees C, there is a problem from which shielding on a plate carries out a thermal shield, and can protect a substrate temperature rise.
[0010] Moreover, the contacts (spring material of phosphor bronze etc.) which impress high frequency are distorted in response to heat to the substrate dome which will be rotated if a substrate is heated at about 300 degrees C. The spring effectiveness of carrier beam contact is lost, contact resistance increases a thermal strain

to a substrate dome, and there is a problem of it becoming impossible to supply high-frequency power. The optical thickness gage and monitoring substrate with which the membrane formation equipment for optics carries out observation control of the thickness are equipped. In this case, since high-frequency power is not impressed to the monitoring substrate, there is a problem that the substrate on a substrate dome and the difference in a refractive index arise.
[0011]
[Summary of the Invention] This invention tends to solve the above troubles and aims at offering the optical thin-film-fabrication equipment which can produce efficiently an optical thin film with the property for which it asks by high pack density in a short time.
[0012] This invention tends to carry out abridgement of the view of impressing RF (RF) power as shown in said JP,51-23376,B to a substrate, and obtaining an adhesive good metal thin film also to the equipment which manufactures an optical (dielectric) thin film. Since two or more ion guns or plasma guns to install are needed when it is going to enlarge the equipment of the method which forms membranes while using ion and the plasma together, in case the optical thin film of high pack density is obtained, it is not practical in price. Then, its attention was paid to the method (direct RF substrate impression method) which impresses a direct RF (frequency band of 13MHz) to a substrate dome. The principle of a direct RF substrate impression method tends to make the ion accelerated by the negative auto-bias by which induction is carried out to the substrate produced from the electron under glow discharge, the difference of the mobility of ion, etc. the bombardment on a film front face, and tends to raise membranous pack density.
[0013] While specifically impressing high-frequency power to the substrate dome to rotate, since [this invention equipment] it is usable also as a conventional vacuum deposition method, the device in which a substrate is heated has been equipped, but in order that this substrate dome may impress high-frequency power efficiently also in the state of an elevated temperature, it has the high-frequency power feed device through the contact which consists of 2 sulfuration tungsten (WS2) and 2 molybdenum sulfides (MoS2) of self-lubricant. In case the same power as the high-frequency power impressed to a substrate dome is supplied to a monitoring substrate, in order to control abnormality discharge, the monitor cylinder and the monitor set plate are made into the structure insulated from a vacuum tub using the insulating member. Moreover, in order to control the abnormality discharge between a substrate dome and a substrate heating heater dome, mounting beam shielding is made into mesh structure among both. In order to raise substrate temperature efficiently, he wants, as for the mesh to be used, to enlarge the aperture of the eye of a mesh, but if the aperture of the eye of a mesh is enlarged too much, the nonconformity whose shielding effect to discharge is lost will occur. From these reasons, the mesh to be used is #2.5 mesh (the aperture of an eye: about 9mm) from #9 mesh (the aperture of an eye: about 2mm), and can perform substrate heating efficiently by having used this mesh. Furthermore, in order to improve the refractive index of the substrate dome periphery section by the difference in the plasma consistency in the substrate dome periphery section, the device which carries out adjustable [of the spacing of a substrate dome and shielding of a periphery] was established.
[0014]
[Embodiment of the Invention] The example of this invention is explained based on a drawing below explanation of the configuration of an example. In addition, said what of drawing 1 is conventionally the same as that of a configuration or equal shall attach the same sign.
[0015] Drawing 2 shows the outline block diagram of the optical thin-film-fabrication equipment of this invention. In this drawing, a sign (1) shows the vacuum tub equipped with evacuation opening (2) and a gas inlet (3), and an evaporation source (6) and a thermionic emission device (8) are prepared in shielding (13) which made the substrate (4) a mounting beam substrate dome (5) and mesh structure inside this vacuum tub (1), and the location which counters. Between this substrate dome (5) and an evaporation source (6), a shutter (10) is prepared free movable, and high-frequency power is supplied to this substrate dome (5) from a high-frequency power feed device (16) through a matching box (15) from an external RF generator (14). At this time, this substrate dome (5) is rotated through a substrate dome rolling mechanism from the motor for a substrate dome revolution of the exterior which is not illustrated. It is going to obtain a desired optical thin film, carrying out observation control of the optical thin film deposited on the monitoring substrate (11) formed near this substrate dome (5) by the external optical thickness gage (12).
[0016] Drawing 3 is the detail drawing of a high-frequency power feed device (16). In this drawing, the sign

(17) showed the monitor cylinder and made the monitor cylinder (17) which is the structure which sets a monitoring substrate (11) the device electrically insulated from a monitor set plate (22) using an insulating member (18) inside the monitor cylinder (17). The shadow area of drawing 3 showed the part to which a RF is impressed. A RF uses 2 sulfuration tungsten (WS2) contact (21) of self-lubricant, is carrying out the pressure welding of the WS2 contact (21) to a substrate dome (5) by Spring S, and has structure which can be efficiently impressed to the substrate dome (5) to rotate.
[0017] Drawing 4 is detail drawing which attaches a monitor cylinder (17) in a monitor set plate (22) by the insulating member (18), the insulating member (19), and the insulating member (20). In this drawing, a sign (17) shows a monitor cylinder and sets a monitoring substrate (11) to the interior of a monitor cylinder. In order that a monitor cylinder (17) might be made into the device electrically insulated from a monitor set plate (22) using an insulating member (18) and might prevent abnormality discharge further, it was made into the device electrically insulated also from a vacuum tub using an insulating member (19) insulating member (20). The shadow area of drawing 4 showed the insulating member.
[0018] Drawing 5 shows the detail drawing which carries out adjustable [of the spacing with shielding (13) of a substrate dome (5) and mesh structure]. Shielding (13) is fixing the tabular structure to a substrate heating heater dome (23) and a vacuum tub (1) with the screw. When changing spacing with a substrate dome (5), it is changing the fixed position of a slot (a) which was able to be opened in the plate of shielding (13), and restopping, and is considering as the structure which can carry out adjustable to a longitudinal direction by being able to carry out adjustable [of the spacing] to a lengthwise direction, and restopping the fixed position of the slot (b) of a vacuum tub (1).
[0019] In the configuration of the explanatory view 2 of an operation and actuation of an example, the interior of a vacuum tub (1) is beforehand exhausted with evacuation opening (2) to a high vacuum field (about 5x10 - 4Pa). About 8x10-3 to 3x10 - 2Pa (in this case, oxygen) of gas for discharge is introduced by the pressure from that blasting-fumes inlet (3). If high-frequency power is impressed to a substrate dome (5) with 2 sulfuration tungsten (WS2) contact (21) (50W-3kW), glow discharge will occur to a substrate dome (cathode electrode) and space with an evaporation source (6), and it will be in the plasma state. In the front face of the substrate (4) attached in this substrate dome (5), the negative direct-current electric field by which self-induction was carried out arise. It is accelerated by the negative direct-current electric field by which self-induction was carried out to the substrate front face, and the plasma-ized gas for discharge rushes into a substrate front face. If power (600W-3600W) is supplied to an evaporation source (6) in this condition and an evaporation source shutter (10) is released, the evaporation particle which evaporated from the evaporation source (6) will pass through the inside of this plasma, and will reach a substrate. Observation control of the thin film deposited on a monitoring substrate (11) is carried out by the optical thickness gage (12), and an evaporation source shutter (10) is closed in the place which became desired thickness. Many high-speed particles exist in plasma discharge space. This high-speed particle collides with a substrate dome (5) and a substrate (4) during thin film formation, and the effectiveness by effectiveness, atomic diffusion, acceleration of combination which give kinetic energy is considered to be a reason for the ability to obtain the thin film of high pack density.
[0020] Drawing 6 expresses the comparison data of the refractive index at the time of forming membranes using the optical thin-film-fabrication equipment of direct RF substrate impression of this invention as the forming-membranes method which used the ion gun while using conventional ion and the conventional plasma together. The case where 5 tantalum oxide (Ta 2O5) with a thickness of 200nm is formed on a substrate with a diameter of 76.2mm on condition that the 1.3x10 to 2 Pa pressure by the oxygen ambient atmosphere, 1kW of high-frequency power, and vapor rate 0.5 nm/s using the substrate dome diameter of 600mm is shown. Refractive-index distribution was measured by the ellipsometer (observation wavelength: 632.8nm) so that a triple digits refractive index could be judged below decimal point. The axis of abscissa of drawing 6 shows the distance from a substrate dome core, and an axis of ordinate shows a refractive index. In the case of the method of forming membranes, while using conventional ion and the conventional plasma together, in the case of the optical thin-film-fabrication equipment of this invention, refractive-index distribution is as large as 0.003, and what the refractive-index distribution covering the whole substrate had by about 0.1 has been improved.
[0021] Drawing 7 is insulating a monitor cylinder (17) and a monitor set plate (22) from a vacuum tub (1) using an insulating member, and means that high-frequency power can be supplied to stability. An impedance outputs the RF generator for plasma generating (14) by the cable which is 50ohms. However, if direct continuation of

not 50ohms but the cable is carried out to a load, an echo of RF power by mismatching of an impedance may be produced, the electric power supply to a load may not be made efficiently, loss of power may increase inside an RF generator, an unusual electrical potential difference may occur, and load impedances (a high-frequency power feed device (16), substrate dome (5), etc.) may damage a power source. In order to decrease this reflective power and to perform impedance matching, there is a matching box (15). The matching box (15) makes impedance matching possible, even if it changes a load impedance broadly by adjustment of two variable condensers by the device and structural change inside a vacuum tub, or change of membrane formation conditions. In case the power of the same RF as the high-frequency power impressed to a substrate dome is impressed to a monitoring substrate (11), in order to control abnormality discharge by this invention, electric power was able to be efficiently supplied to the substrate dome (5) in the RF by having made the monitor cylinder (17) and the monitor set plate (22) into the structure insulated from a vacuum tub (1) using the insulating member. When the pressure of 2.7 to 1.3xten - two Pa by the oxygen ambient atmosphere and the RF output of 1.5kW were impressed continuously, using the substrate dome diameter of 760mm as an example, and only a monitor cylinder (17) was insulated, abnormality discharge occurs after [of RF impression] 10 minutes, and high frequency discharge stopped continuing in 22 minutes (unusable). By having adopted the device in which a monitor set plate (22) was insulated with a monitor cylinder (17) from a vacuum tub (1) on the other hand, it was stabilized even if it carried out continuation impression of the RF 30 minutes or more, and power was able to be supplied. The axis of abscissa of drawing 7 shows time amount, and an axis of ordinate shows RF reflective power.

[0022] Drawing 8 shows that a substrate dome can supply electric power to stability in high-frequency power also in the state of an elevated temperature by using the high-frequency power feed device (16) which consists of 2 sulfuration tungsten (WS2) contact (21) of self-lubricant, in order that the substrate dome (5) to rotate may impress high-frequency power efficiently also in the state of an elevated temperature. As feed zone material of power, there is a contact spring (Cu contact) made from copper (Cu). However, substrate temperature rises, degradation of Cu contact starts above 180 degrees C, and high frequency discharge is not continuing (an activity being impossible) above 200 degrees C. In this invention, the substrate (4) was able to impress high-frequency power efficiently by adopting self-lubricant 2 sulfuration tungsten (WS2) contact (21) also in the state of the elevated temperature 300 degrees C or more. The axis of abscissa of drawing 8 shows substrate temperature, and an axis of ordinate shows RF reflective power.

[0023] Drawing 9 shows that substrate heating can be efficiently carried out by making mounting beam shielding (3) into mesh structure among both, in order to control the abnormality discharge between a substrate dome (5) and a substrate heating heater dome (23). Using the substrate dome diameter of 760mm, a glass substrate with a diameter of 30mm is installed on a dome, and it heats, controlling automatically the power supplied to a substrate heating heater dome (23) by setting temperature as a thermoregulator. The substrate thermometry was measured with the radiation thermometer measurable by non-contact. In the case tabular (thickness: 1-2mm, construction material:stainless steel) in shielding, as compared with the time of there being no shielding, it was temperature low 150 degrees C. It is improvable by making shielding into mesh structure with this invention with the almost same temperature low 10 degrees C as the time of there being no shielding. The axis of abscissa of drawing 9 R> 9 shows thermoregulator laying temperature, and an axis of ordinate shows substrate temperature.

[0024] Drawing 10 expresses the wavelength movement magnitude (the amount of wavelength shifts) at the time of forming membranes using the method of forming membranes, while using conventional ion and the conventional plasma together. The substrate dome diameter of 600mm is used and it is Ta 2O5 on a substrate with a diameter of 30mm. 25 layers of SiO2 thin films were deposited by turns. The pressure of 2.7 to 1.3xten - two Pa by the oxygen ambient atmosphere, the anode output of 900mA, 900V, vapor rate Ta 2O5 Membranes were formed on condition that 0.1 nm/s and SiO2 0.1 nm/s. Measurement of the amount of wavelength shifts carried out spectral transmittance measurement, before and after carrying out an environmental test, and it evaluated it, judging from the amount of gaps of the spectral characteristic. The environmental-test approach left the substrate which formed membranes for 1000 hours in the ambient atmosphere of the temperature of 85 degrees C, and 95% of humidity. The axis of abscissa of drawing 10 shows wavelength, and an axis of ordinate shows permeability. In the case of the method of forming membranes, while using conventional ion and the conventional plasma together, the amount of wavelength shifts was 1-2nm.

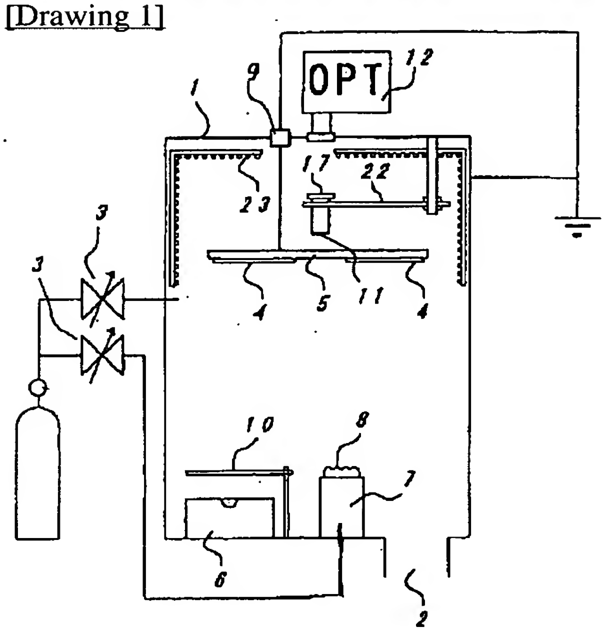
[0025] Drawing 11 expresses the wavelength movement magnitude (the amount of wavelength shifts) at the time of forming membranes using the optical thin-film-fabrication equipment of this invention. The substrate dome diameter of 600mm is used and it is Ta 2O5 on a substrate with a diameter of 30mm. 25 layers of SiO2 thin films were deposited by turns. The pressure of 2.7 tò 1.3xten - two Pa by the oxygen ambient atmosphere, the RF output of 1kW, vapor rate Ta 2O5 Membranes were formed on condition that 0.5 nm/s and SiO2 0.6 nm/s. Measurement of the amount of wavelength shifts carried out spectral transmittance measurement, before and after carrying out an environmental test, and it evaluated it, judging from the amount of gaps of the spectral characteristic. The environmental-test approach left the substrate which formed membranes for 1000 hours in the ambient atmosphere of the temperature of 85 degrees C, and 95% of humidity. The axis of abscissa of drawing 11 shows wavelength, and an axis of ordinate shows permeability. The amount of wavelength shifts at the time of forming membranes with the optical thin-film-fabrication equipment of this invention was 0.1nm or less. If compared by the case where the amount of wavelength shifts is formed with the optical thin-film-fabrication equipment of the method of forming membranes while using ion and the plasma together, and this invention, in the case of the optical thin-film-fabrication equipment of this invention, what the shift amount of the method of forming membranes while using conventional ion and the conventional plasma together had by 1-2nm will be large to 0.1nm or less and 1/10, and it will have been improved.
[0026] Drawing 12 compares the membrane formation processing time at the time of forming membranes using the optical thin-film-fabrication equipment of this invention with the method of forming membranes, while using conventional ion and the conventional plasma together. The substrate dome diameter of 760mm is used and it is Ta 2O5 about an about [wavelength:lambda=600nm] PBS filter. It deposited by the membrane formation technique of each 20 layer in alternation using SiO2. They are the pressure of 2.7 to 1.3xten - two Pa according [the method of forming membranes, while using ion and the plasma together on the other hand] to an oxygen ambient atmosphere, the anode output of 900mA, 900V, and a vapor rate Ta 2O5. Membranes were formed on condition that 0.1 nm/s and SiO2 0.2 nm/s. They are the pressure of 2.7 to 1.3xten - two Pa according [the membrane formation conditions of this invention] to an oxygen ambient atmosphere, the RF output of 1kW, and a vapor rate Ta 2O5. Membranes were formed on condition that 0.5 nm/s and SiO2 1.0 nm/s. The axis of abscissa of drawing 12 shows the membrane formation technique, and an axis of ordinate shows time amount.
[0027] When the membrane formation processing time at the time of forming membranes, respectively with the optical thin-film-fabrication equipment of the method of forming membranes while using ion and the plasma together, and this invention is compared, there are [almost same] membrane formation preparation and 1.5 substrate ejection time amount in total. The membrane formation processing time is as large as one fifth, and, as for the case of the optical thin-film-fabrication equipment of this invention, what existed in about 10 hours in the case of the method of forming membranes while membrane formation time amount uses conventional ion and the conventional plasma together has been improved in 2 hours.
[0028] Drawing 13 is equipment of this invention and shows the refractive-index distribution in a dome at the time of changing a dome and shielding spacing and forming membranes. It is TiO2 using the substrate dome diameter of 1150mm at the conditions of the pressure of 2.7xten - two Pa by the oxygen ambient atmosphere, the RF output of 3kW, and vapor rate 0.3 nm/s**. 200nm formed membranes. The axis of abscissa of drawing 13 shows the distance from a substrate dome core, and an axis of ordinate shows a refractive index. If the refractive-index distribution in a dome at the time of forming spacing of a substrate dome and shielding by 30mm and 60mm, respectively is compared, the refractive-index values 2.399-2.406 with a substrate dome core to about 500 almost samemm are shown, but when spacing of a dome and shielding is 60mm, by 500-540mm, the refractive index is falling extremely with 2.385 from the substrate dome core. Why a refractive index falls is generated in the difference in the plasma consistency in a substrate dome core and a periphery. the until [comparable] improvement was able to be mostly carried out with the refractive index 2.404 and the refractive-index value from a substrate dome core to about 500mm by considering as the device which can carry out adjustable [of the spacing with shielding] this time, and setting spacing of a dome and shielding to 30mm.
[0029] The structure of this invention can be diverted to all membrane formation equipments that carry out substrate impression of the RF. Drawing 14 is what showed the example diverted to some other purpose to the sputtering system, and the big difference from the optical thin-film-fabrication equipment of this invention shown by drawing 2 is the sputtering system made into the structure where high frequency and direct current

power are impressed to a sputtering target (24) through a power-source circuit changing switch (26).
[0030]
[Effect of the Invention] While impressing high-frequency power directly in this invention to the substrate dome to rotate By having adopted the high-frequency power feed device of this invention, the discontinuous construction for controlling abnormality discharge, the mesh structure of shielding for performing substrate heating efficiently, the device that carries out adjustable [of the shielding spacing of a substrate dome and a periphery] further, etc. That whose refractive-index distribution in a substrate dome was 0.1 conventionally is improved 0.003, and what was 1-2nm also improves wavelength movement magnitude (the amount of wavelength shifts) to 1/10 to 0.1nm conventionally. Furthermore, what also needed the membrane formation processing time conventionally for 10 hours was shortened to one fifth to 2 hours. Thus, by this invention, it became possible to produce efficiently the optical thin film which is [the optical (dielectric) thin film of high pack density] proud of a good refractive index throughout the inside of a substrate dome for a short time, and the productivity of optics and an electron device product was improved remarkably. The industrial value is dramatically remarkable.

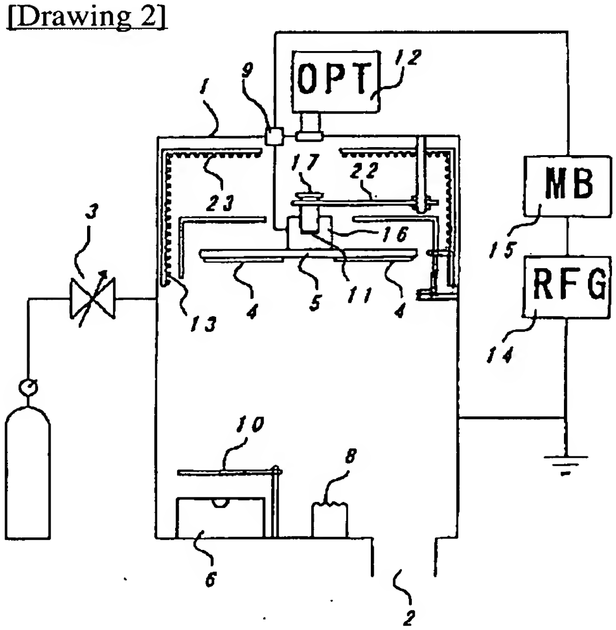
[Translation done.]

DRAWINGS

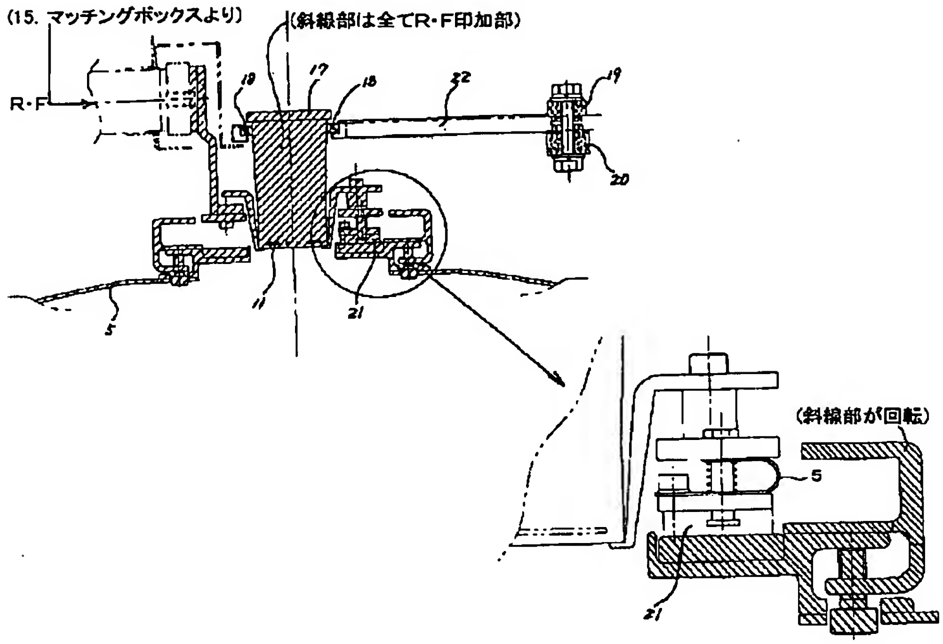
[Drawing 1]



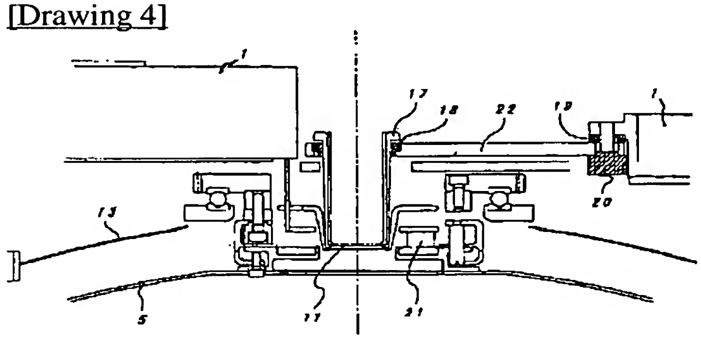
[Drawing 2]



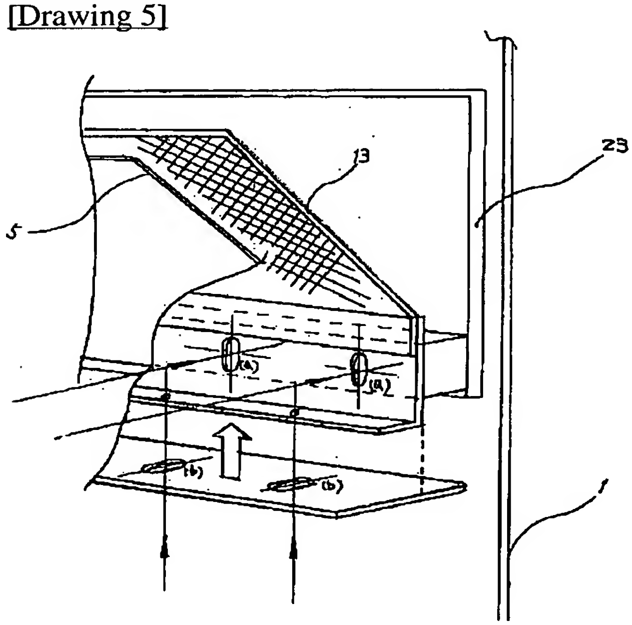
[Drawing 3]



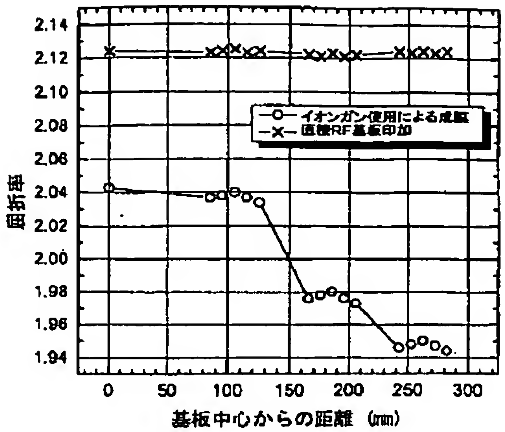
[Drawing 4]



[Drawing 5]



[Drawing 6]



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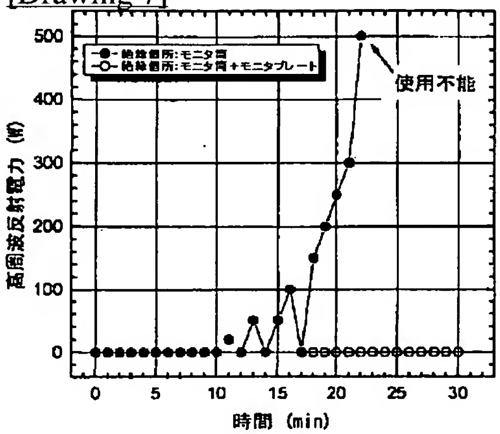
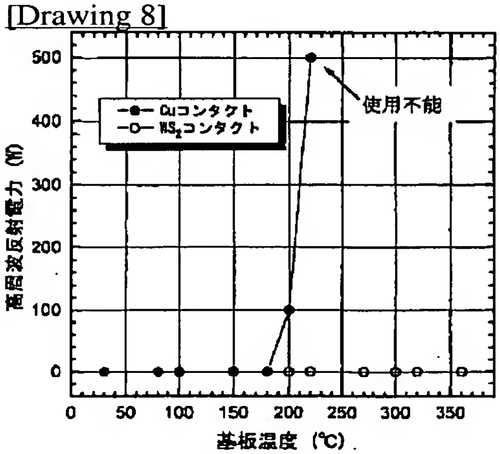
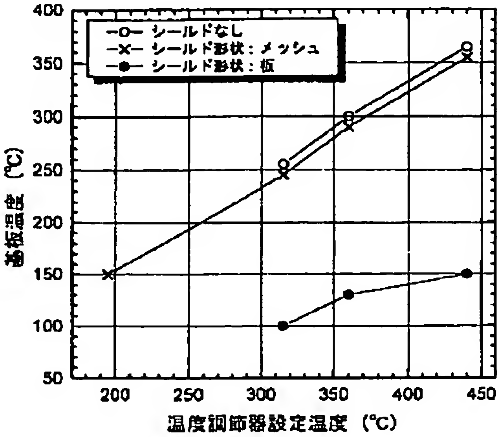


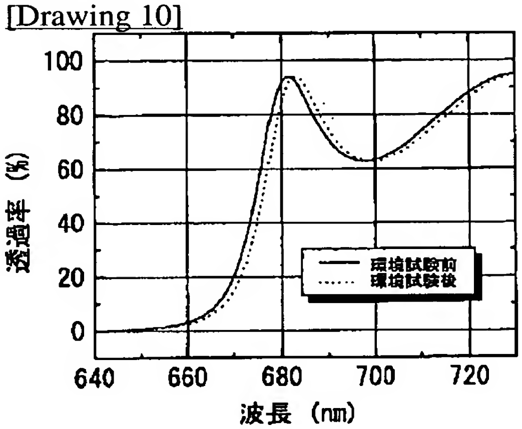
[Drawing 8]



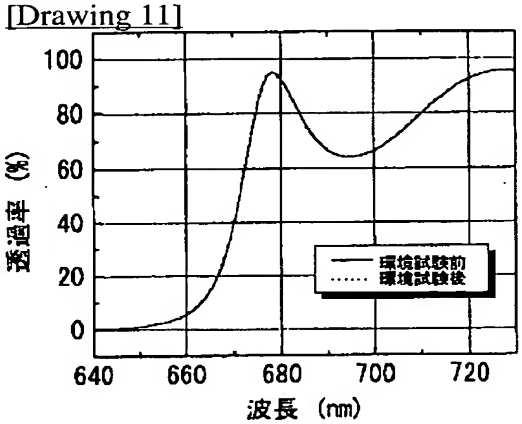
[Drawing 9]



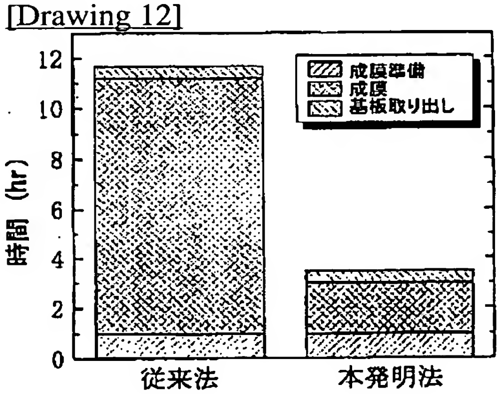
[Drawing 10]



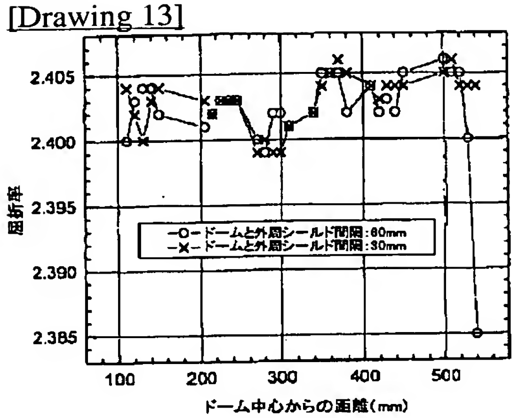
[Drawing 11]



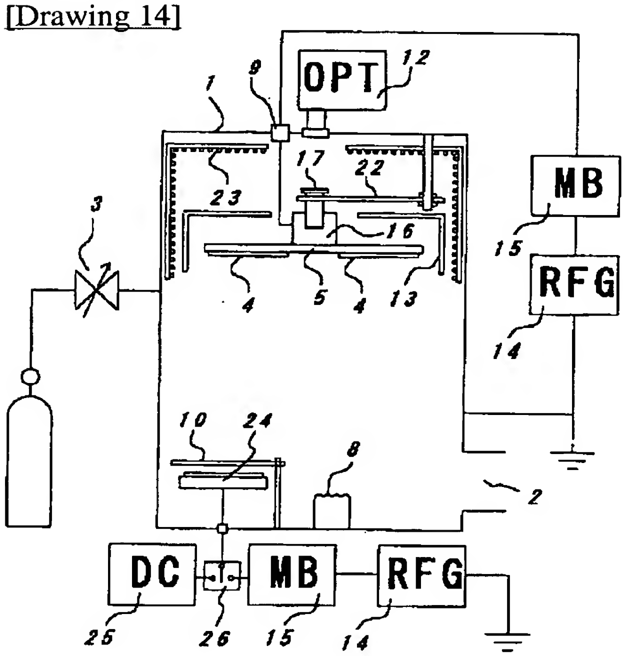
[Drawing 12]



[Drawing 13]



[Drawing 14]



[Translation done.]